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Functional Perfusion studies of Motor Cortex during Task and Rest States using QUIPSS at 3T

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INTRODUCTION

QUIPSS (QUantitative Imaging of Perfusion using a Single Substraction) (1) is a pulsed arterial spin labeling technique that allows for quantitative perfusion imaging using a simple substraction of two images. In this study we performed QUIPSS during task and rest states in the motor cortex at 3T. At high field strength, spin tagging techniques benefit due to the high signal-to-noise ratio (SNR) and long T_1 of blood. We performed TI stepping to obtain information about the transit time and perfusion on a voxel-wise basis.

METHODS

All images were acquired using a 3T Bruker Biospec 30/60 scanner. A 30.5 cm i.d. three-axis local head gradient coil (2) and an endcapped quardrature birdcage coil were used. In QUIPSS, at a time TI_1 after inversion of arterial blood, the imaging slice is saturated, and an image is acquired at a later time TI_2. A single-shot gradient echo blipped echo planar imaging (EPI) pulse sequence was used for readout with FOV of 24 cm at a resolution of 64x64, and TE/TR of 27.2/2000 ms. The slice thickness was 10 mm and a 30 mm slice selective inversion was used. TI_1 was varied from 400 ms to 1400 ms with 200 ms intervals. ΔTI ($=TI_2 - TI_1$) was fixed at 400 ms. The T_1 of blood at 3T was assumed to be 1400 ms. At each TI_1 value, a time series of 100 sequential images of one axial slice through the motor cortex was obtained during cyclic (40 sec on, 40 sec off) bilateral finger tapping. QUIPSS images were processed by performing pairwise substraction of consecutive images collected at TI_2, creating a time series of perfusion images. Functional perfusion images were generated by substraction of the resting and active state perfusion maps, which were generated by averaging the periods of rest and activation respectively. Baseline perfusion images were generated by averaging of the whole time seires. Functional BOLD contrast images were generated as above from the portion of the QUIPSS data set that used non-selective inversion.

RESULTS

A BOLD contrast image of motor cortex with TI_1/TI_2 = 800/1200 ms is shown in Fig. 1a and the corresponding calculated QUIPSS perfusion image is shown in Fig. 1b. Figure 1c is the baseline perfusion map at the same TI_1/TI_2. A plot of the calculated average perfusion over the entire slice, excluding the sagittal sinus, vs TI_1 is shown in Fig. 2a. Figure 2b shows the calculated average perfusion over those activated pixels of motor cortex during task (●) and rest (○) states. Average perfusion of unactivated rest state pixels in gray and white matter are indicated by (▽) and (◇) respectively. Perfusion ratio of task state to rest state is 1.3, and the gray to white matter perfusion ratio is 6.6 at TI_1/TI_2 = 800/1200 ms. Perfusion during rest and task states vs TI_1 from the 16 pixel region outlined in Fig. 1c are shown in Fig. 3. The left half in each of the 16 squares contains the calculated perfusion at different TI_1 during rest state while the right half contains data during task state.

DISCUSSION

With TI stepping, the arrival of inflowing blood and transit time information as well as perfusion are observed in each pixel. At short TI, low perfusion signal does not necessarily mean low perfusion, it could be a consequence of long transit time in those voxels. For perfusion measurements, it is important to account for the different delays in each voxel that contributes to the perfusion signal.

REFERENCES

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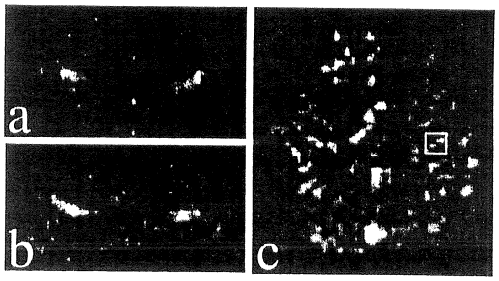

Figure 1. a) BOLD difference image. b) QUIPSS perfusion image. c) Baseline perfusion map.

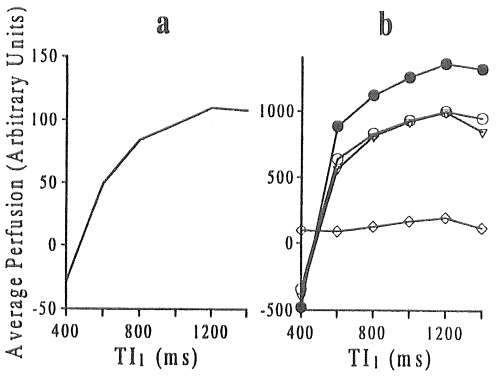

Figure 2. Average perfusion of different pixel groups vs TI_1 with ΔTI = 400 ms.

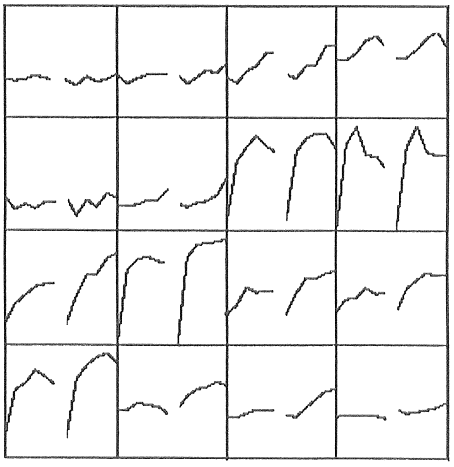

Figure 3. Perfusion during rest (left) and task (right) states vs TI_1 from the 16 pixel region outlined in 1c.